Codes and Standards Support for Vehicle Electrification

2013 DOE Hydrogen Program and Vehicle Technologies Annual Merit Review

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Sponsored by Lee Slezak

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U.S. DEPARTMENT OF **ENERGY**

Overview

Timeline

- Support of PEV-Grid related standards, including communication started 2007
- SAE J2954 Wireless PEV Charging standard initiated in 2010
- SAE J2953 PEV-EVSE Interoperability Standard initiated in 2010; ANL Lead committee starting in 2012
- ISO15118-pt6 Interoperability for DC Charging communication started 2012

Budget

- FY2010- $300k
- FY2011- $400k
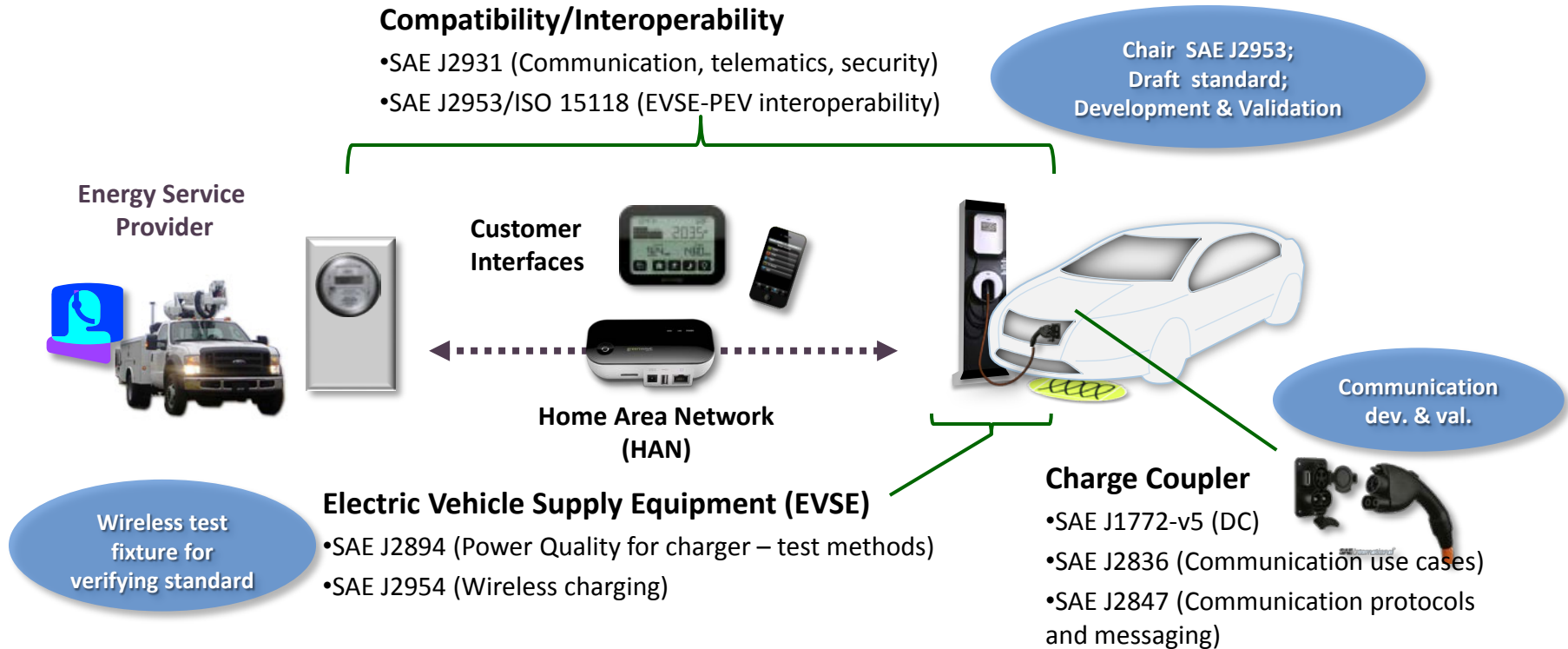- FY2012- $280k
- FY2013- $400k

Barriers

- **A.** Establishing consensus between competing approaches to intelligently manage vehicle charge and communication
- **B.** Interoperability of vehicle-grid communication and hardware connections is a necessity for effective infrastructure deployment
- **C.** Low cost, secure, validated technology and communication standards are required coincident with PHEV/EV market introductions

Partners

- Utilities (DTE Energy, Southern Cal. Edison, Commonwealth Edison, Northeast Utilities, TVA, Communications technology vendors)
- EVSE suppliers (Clipper Creek, Coulomb, SPX, Leviton, ECOtality, G.E., Schneider)
- Vehicle OEMS (Ford, GM, Chrysler, BMW)
- National Labs (INL, PNNL, ORNL, NREL)
- NRTL Certification Labs (UL, ETL, TUV SUD)

Approach – Direct Participation

Compatibility/Interoperability
- SAE J2931 (Communication, telematics, security)
- SAE J2953/ISO 15118 (EVSE-PEV interoperability)

Chair SAE J2953; Draft standard; Development & Validation

Energy Service Provider

Customer Interfaces

Home Area Network (HAN)

Wireless test fixture for verifying standard

Electric Vehicle Supply Equipment (EVSE)
- SAE J2894 (Power Quality for charger – test methods)
- SAE J2954 (Wireless charging)

Communication dev. & val.

Charge Coupler
- SAE J1772-v5 (DC)
- SAE J2836 (Communication use cases)
- SAE J2847 (Communication protocols and messaging)

- Continuously assess state-of-the art and guide committees
- Participate with IEEE and NFPA; charger wiring and installation requirements
- Participate with NIST; smart grid standards for utility network and sub-meter requirements (includes ANSI, NEMA and CPUC to address gaps identified by EPRI)
- Evaluate and validate hardware and communication protocol proposals
- Support USG initiatives regarding international harmonization

Milestones

Simplifying SAE and other Standards Defining Organizations (SDOs) supported by ANL-- the four primary areas include:

1) **Conductive AC Charging** (coupler evolution, communication, interoperability)

2) **Conductive/Combo DC Charging** (powerline communication, protocols, validation)

3) **Wireless Non-contact Charging** (safety, freq. allocation, definitions, test procedures)

4) **Smart Grid Related Interactions** (between utility programs and vehicles on charge)

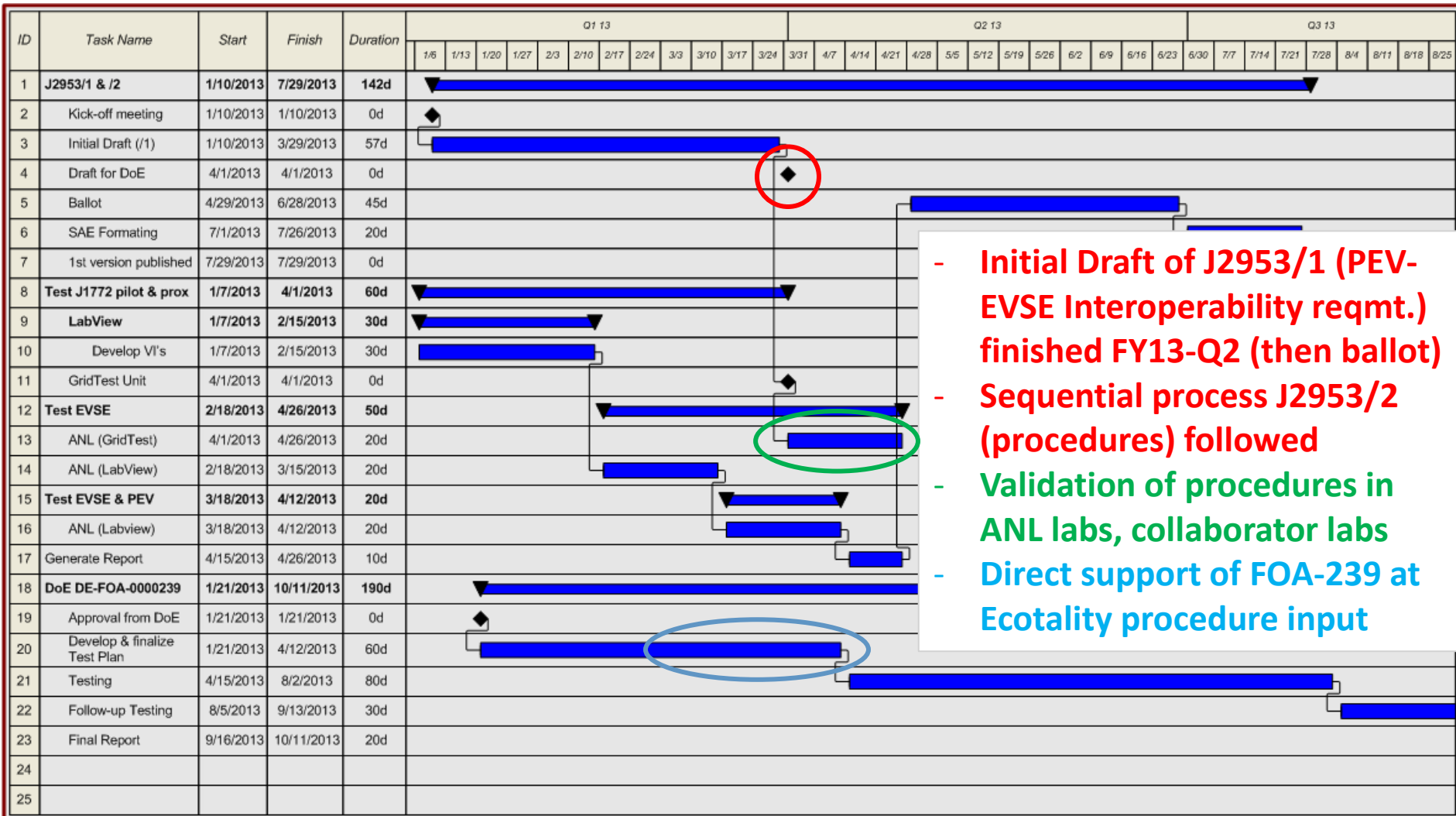**ANL Specific Milestones on the above Areas include:**

- **Charge coupler (SAE J1772v5)** passed by Motor Vehicle Council Aug 2012-; ANL UL cert. input (FY12Q3) DC Level 1 and DC Level 2 clarifications on safety/interlock reqmt.

AC/DC Charging Communication; Interoperability

- Implemented and conducted tests of proposed communication software with suppliers to identify gaps/errors and provide data to support next draft of J28478/2

- Lead author and chair of SAE J2953 PEV-EVSE Interoperability. Created collection of EVSE test articles on a common framework for GridTest EVE-100S test equipment. Preliminary results used to validate requirements of J2953/1 draft sent to ballot Q2-13.

Milestones Linked to SAE Standards
(ANL Led J2953 PEV-EVSE Interoperability example)

ID	Task Name	Start	Finish	Duration
1	J2953/1 & /2	1/10/2013	7/29/2013	142d
2	Kick-off meeting	1/10/2013	1/10/2013	0d
3	Initial Draft (/1)	1/10/2013	3/29/2013	57d
4	Draft for DoE	4/1/2013	4/1/2013	0d
5	Ballot	4/29/2013	6/28/2013	45d
6	SAE Formating	7/1/2013	7/26/2013	20d
7	1st version published	7/29/2013	7/29/2013	0d
8	Test J1772 pilot & prox	1/7/2013	4/1/2013	60d
9	LabView	1/7/2013	2/15/2013	30d
10	Develop VI's	1/7/2013	2/15/2013	30d
11	GridTest Unit	4/1/2013	4/1/2013	0d
12	Test EVSE	2/18/2013	4/26/2013	50d
13	ANL (GridTest)	4/1/2013	4/26/2013	20d
14	ANL (LabView)	2/18/2013	3/15/2013	20d
15	Test EVSE & PEV	3/18/2013	4/12/2013	20d
16	ANL (Labview)	3/18/2013	4/12/2013	20d
17	Generate Report	4/15/2013	4/26/2013	10d
18	DoE DE-FOA-0000239	1/21/2013	10/11/2013	190d
19	Approval from DoE	1/21/2013	1/21/2013	0d
20	Develop & finalize Test Plan	1/21/2013	4/12/2013	60d
21	Testing	4/15/2013	8/2/2013	80d
22	Follow-up Testing	8/5/2013	9/13/2013	30d
23	Final Report	9/16/2013	10/11/2013	20d
24				
25				

- **Initial Draft of J2953/1 (PEV-EVSE Interoperability reqmt.) finished FY13-Q2 (then ballot)**
- **Sequential process J2953/2 (procedures) followed**
- **Validation of procedures in ANL labs, collaborator labs**
- **Direct support of FOA-239 at Ecotality procedure input**

In Process - SAE J2931/4 and J2847/DC Communication Controller Implementation- Setting Up Interoperability for DC Charging System

- SAE J2931 Powerline Communication over the 1 kHz pilot wire requires a broad range of coexistence, crosstalk and compatibility rigorous yet vendor independent.

- Leveraged Grid Connectivity RD&D Projects (Supply Equipment & Electric Vehicle Communication Controllers {SECC & EVCC}) to implement the SAE J2847/2 DC charging communication protocol, and identify gaps in interoperability with the DIN70121-ISO15118 harmonized DC charging communication standard

- Custom built circuit boards/modules designed and constructed by ANL.
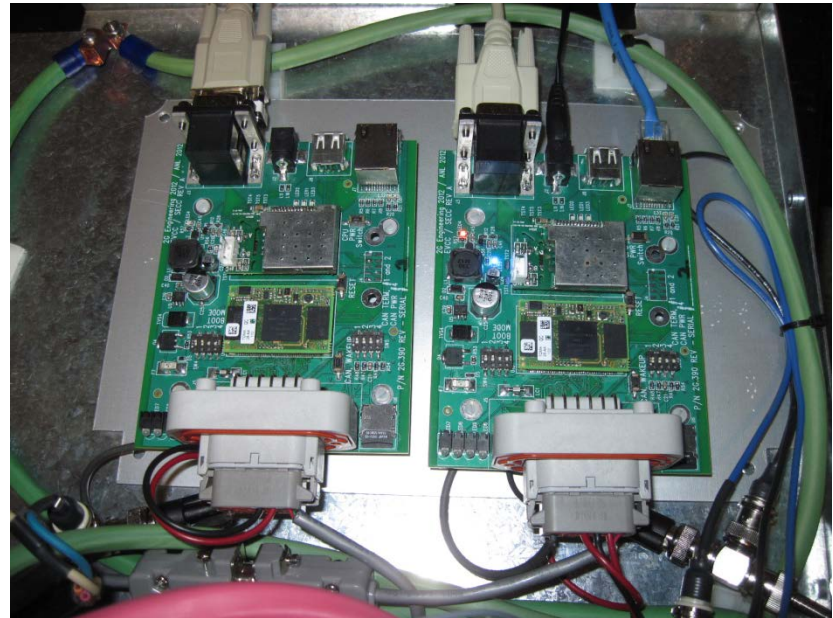
In Process: SAE J2954 Wireless Charging Evaluation and Testing Protocol/Fixtures

- Working with certification parties (UL/TUV SUD-America), charging system vendors and automotive OEMs on a consensus based testing requirements document and protocol leading to a certification criteria.

- Designing, fabricating and evaluating a test fixture to clarify the significance of variability in the test criteria (e.g., mounting surface, ground plane of vehicle, etc.) to refine the charging system performance, safety and communication requirements
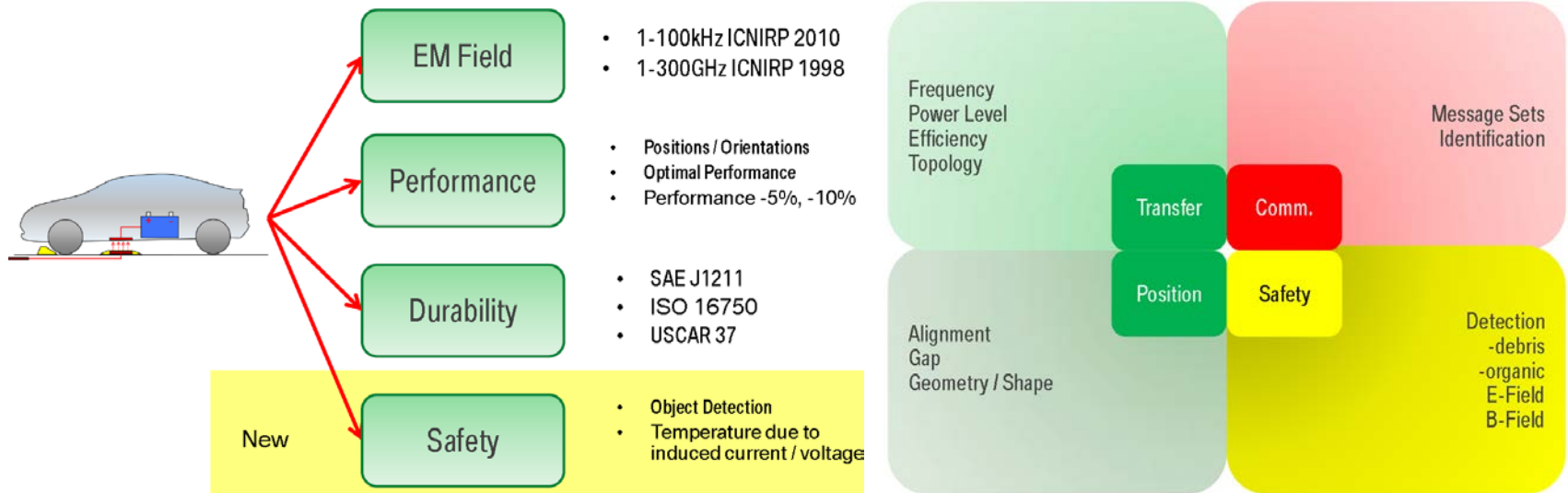
Collaboration

- **SAE J2954 Wireless Charging**
  - UL, TUV SUD-America, ORNL,
  - Vehicle OEMS : GM, Toyota, Nissan, BMW, Daimler, Ford, VW, Audi
  - W-EVSE manufacturers: Evatran, Witricity, Qualcomm-Halo IPT, Momentum Dynamics

- **SAE J2953 PEV-EVSE Interoperability**
  - UL, TUV SUD-America, ETL
  - Vehicle OEMS : GM, Toyota, Nissan, Honda, Mitsubishi, BMW, Daimler, Ford, VW, Audi
  - EVSE manufacturers: ClipperCreek, ChargePoint, Ecotality, Delta Products, DBT, BTCP, etc.

- **SAE J2894 Charger Efficiency/Quality**
  - On-board Charger Manufacturers: Delta-Q, Magna E-Car, TDK, Delphi, Delta Products
  - Utilities: PGE, SCE

- **SAE J2847/2 (ISO15118) DC Charging Digital Communication**
  - Vehicle OEMS : GM, Ford, Chrysler, BMW, VW, Audi
  - DC Charger manufacturers: Eaton, ABB, BTCP, Efacec, Siemens, Qualcomm, Mitsumi

- **SDOs for Codes and Standards:** IEEE, NIST, NFPA, SAE, Industry, Academia, Suppliers, Utilities, National Labs, et.al.

Future Plans

Maintain focus on near-term needs with long-term impact, direct support of SAE standards committees.

(Remaining) FY 2013 Activities

- **SAE standards committee support**
  - Continue to chair SAE J2953 standard for PEV-EVSE Interoperability, finish-publish J2953/1-v1 (requirements) as well as J2953/2-v1 (procedures) and start J2953/1-v2 (addition of DC charging interoperability and higher tiers of interoperability tests).
  - Continue harmonization of SAE J2847/2 (DC Charging) with ISO15118-pt6

- **Sub-metering/communication modules**
  - Continue to leverage advances from the Grid Connectivity RD&D activities at ANL assist in validating assumptions used to create definitions of sub-meters (EUMD) in electric vehicle refueling
  - Use case refinement for sub-metering protocols; further support of CPUC and similar protocol investigations

- **Depowering Protocol Investigation/Fixture development**
  - Continue to participate in SAE and NHTSA project to define and develop depowering standard for post-crash PEVs battery safety.

Activities for Next Fiscal Year

- **Continue to investigate limitations and propose solutions for harmonized vehicle-grid communications technologies with emphasis on interoperability**
  - Guide standards development for technology-neutral outcome
  - Expand on SAE J2XXX/6 (wireless charging communication, use case, protocols, etc.)
  - Expand on SAE J2XXX/3 (bi-directional power flow, including micro-grid implementation of DC and AC charged vehicles, with utility messages)

- **Validate performance targets in a systems context**
  - Wireless charging throughput and safety
  - Grid integration with other EERE technologies

Summary

- **Relevance** – Directly responds to urgent technical needs of the EV-EVSE and EVSE-grid interfaces and directly supports the connectivity and communications committees of SAE.

- **Approach** – Provide technical support to establish cohesive vehicle electrification standards via active participation on standards committees. Provide transformative developments such as creation of proof of concept systems as well as validation of proposed approaches.

- **Technical accomplishments and progress** – Provided leadership, expertise, hardware/software development and laboratory facilities to directly support SAE and other organizations to develop and adopt key EV-grid connectivity standards. Supported DOE FOA556 technical requirements and guidance for awardees

- **Collaborations and Coordination** – GITT activities are well-connected with industry and government agencies (domestic and international).

- **Future Work** – Maintains focus on near-term needs with long-term impact.

Technical Back-Up Slides

Approach: – Support SAE PEV/EVSE Related Standards
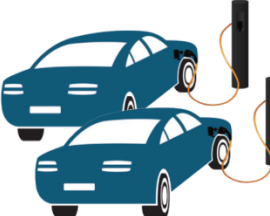
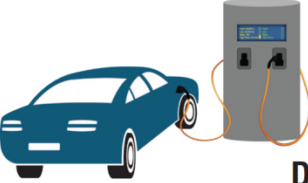| Document Number	Title – Works in Progress
J1772 (v5)	SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler
J2836/3	Use Cases for Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow
J2836/4	Use Cases for Diagnostic Communication for Plug-in Vehicles
J2836/5	Use Cases for Communication between Plug-in Vehicles and their customers.
J2836/6	Use Cases for Wireless Charging Communication between Plug-in Electric Vehicles and the Utility Grid
J2847/1	Communication between Plug-in Vehicles and the Utility Grid
J2847/2	Communication Between Plug-in Vehicles and Off-Board DC Chargers
J2847/3	Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow
J2847/4	Diagnostic Communication for Plug-in Vehicles
J2847/5	Communication between Plug-in Vehicles and their customers
J2847/6	Wireless Charging Communication between Plug-in Electric Vehicles and the Utility Grid
J2894/2	Power Quality Requirements for Plug In Vehicle Chargers - Part 2: Test Methods
J2931/1	Digital Communications for Plug-in Electric Vehicles
J2931/4	Broadband PLC Communication for Plug-in Electric Vehicles
J2931/5	Telematics Smart Grid Communications between Customers, Plug-In Electric Vehicles (PEV), Energy Service Providers (ESP) and Home Area Networks (HAN)
J2931/6	Digital Communication for Wireless Charging Plug-in Electric Vehicles
J2931/7	Security for Plug-in Electric Vehicle Communications
J2953	Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)
J2954	Wireless Charging of Electric and Plug-in Hybrid Vehicles
J2990	Hybrid and EV First and Second Responder Recommended Practice
J3009	Trapped Energy- Reporting and Extraction from Vehicle Electrical Energy Storage System

Approach: Highly Interdependent EVSE and PEV Communication Standards; ANL Covers All of These
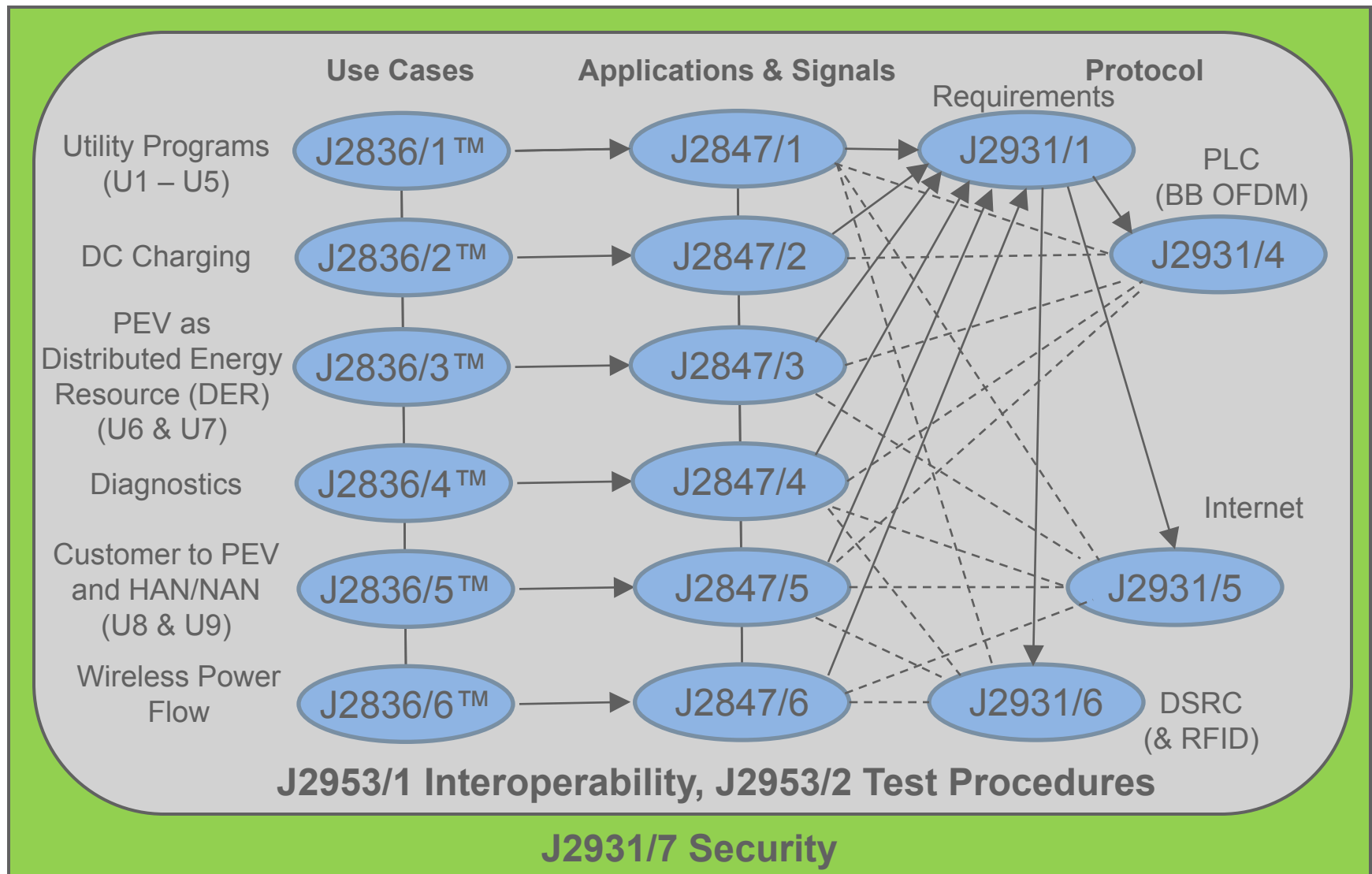
Boundary Between Charging (Power) Levels is Blurred

	Charging Level	Setting	Supply Power	Representative Example	Where Charging Occurs
	AC Level 1	Residential/ Parking Lot 5 mi/hour @ 1.7 kW	120vac/20A (16A continuous)		**RESIDENTIAL**
	AC Level 2 (minimum)	Residential/ Commercial 10 mi/hour @ 3.4 kW	208/240vac/20A (16A continuous)		2/3 of charging
	AC Level 2 (maximum)	Commercial (up to) 60 mi/hour @ 19.2 kW	208/240vac/100A (80A continuous)		
	DC Level 1	Commercial up to 500v @ 80Adc (up to) 120 mi/hour @ 40 kW	208vac/480vac 3-phase (input current proportional to output power; ~20A-200A AC)		**COMMERCIAL**
	DC Level 2	Commercial up to 500v @ 200Adc (up to) 300 mi/hour @ 100 kW	208vac/480vac 3-phase (input current proportional to output power; ~20A-400A AC)		1/3 of charging

EVSEs- J2953 Interoperability/Benchmarking

~40 EVSEs, mounted on skid- testing assets
Some deployed in the field.
Testing Tools- EVE-100, Labview V.I.s

Labview based test rack; AC, DC loads and sources; J1772 signal pass through monitoring/fault injection